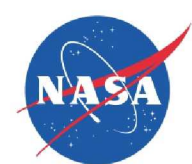




# HypSIRI On-Board Science Data Processing

HypSIRI Symposium  
May 4, 2010

Tom Flatley – Branch Head  
NASA/GSFC Science Data Processing Branch



# On-Board Science Data Processing

## HypSIIRI On-Board Processing

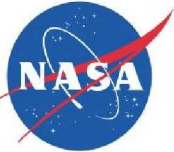
- Data Volume Reduction
- Compression
- Calibration / Correction
- Classification
- Product Generation
- Autonomy
- Event / Feature Detection
- Real-time / Direct Broadcast

## Hybrid Science Data Processing

- CPU
- FPGA
- DSP

## GSFC SpaceCube On-Board Processor

- 10x-100x computing performance
- Lower power (MIPS/watt)
- Lower cost (commercial parts)
- Radiation tolerant (not hardened)
- Software upset mitigation



# On-Board Image Processing



STS-125 Payload Bay

## Long Range Camera on Rendezvous

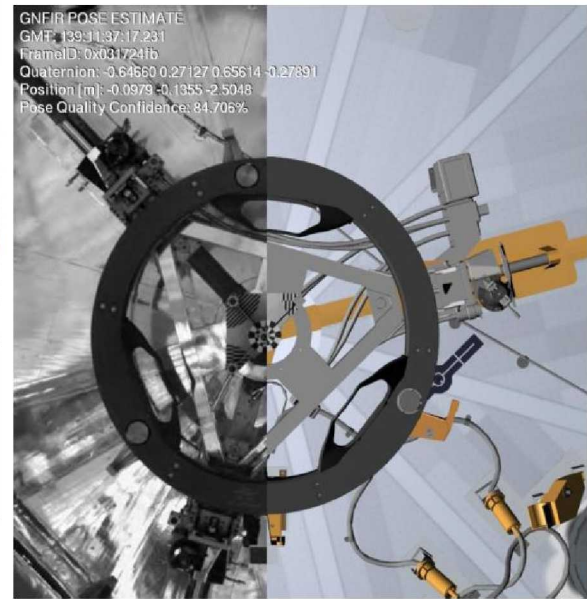


Flight Image

RNS Tracking Solution

GNFIR POSE ESTIMATE  
GMT: 133:16:28.43.757  
Frame ID: 0x73F13002  
Quaternion: 0.72654, -0.67387, 0.03428, 0.12983  
Position (meters): 1.4498, 7.8250, -81.4431  
Pose Quality Confidence: 88.235%

## Short Range Camera on Deploy

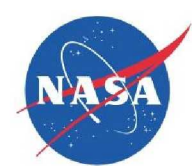


Flight Image

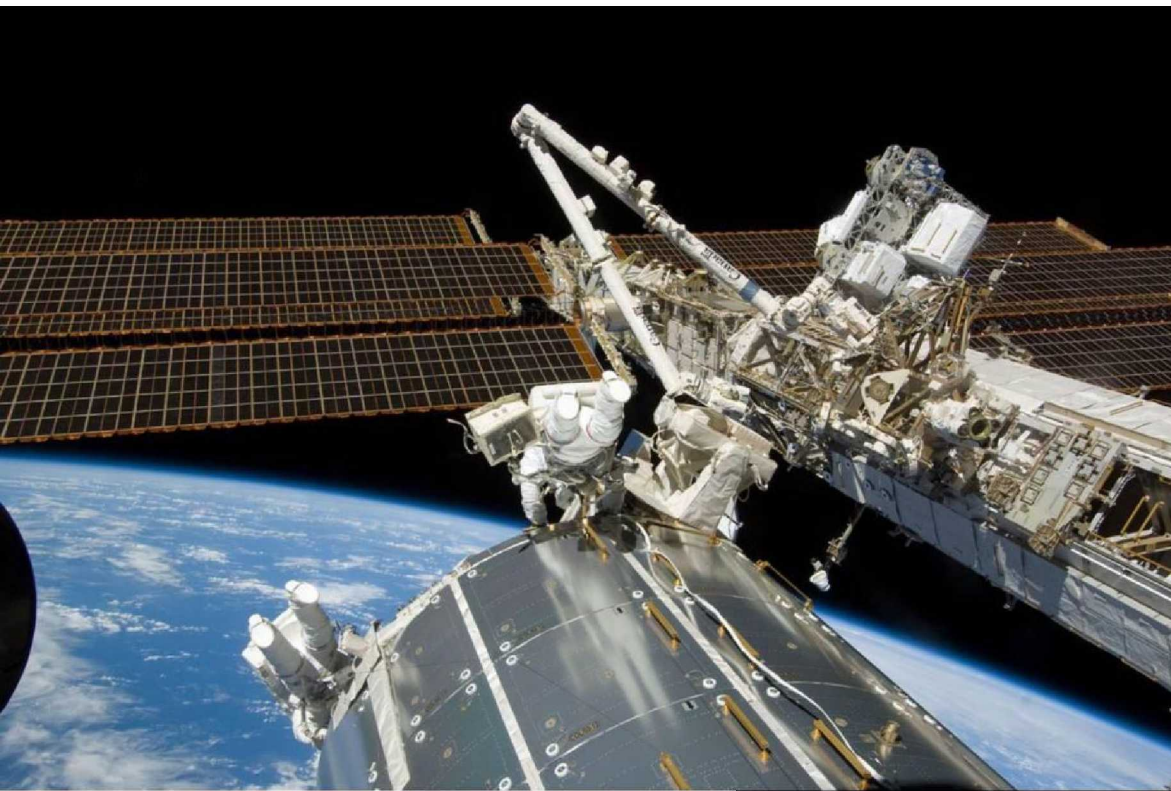
RNS Tracking Solution

GNFIR POSE ESTIMATE  
GMT: 139:11:37:17.231  
FrameID: 0x031724fb  
Quaternion: -0.64660 0.27127 0.65614 -0.27891  
Position [m]: -0.0979 -0.1055 -2.5048  
Pose Quality Confidence: 84.706%

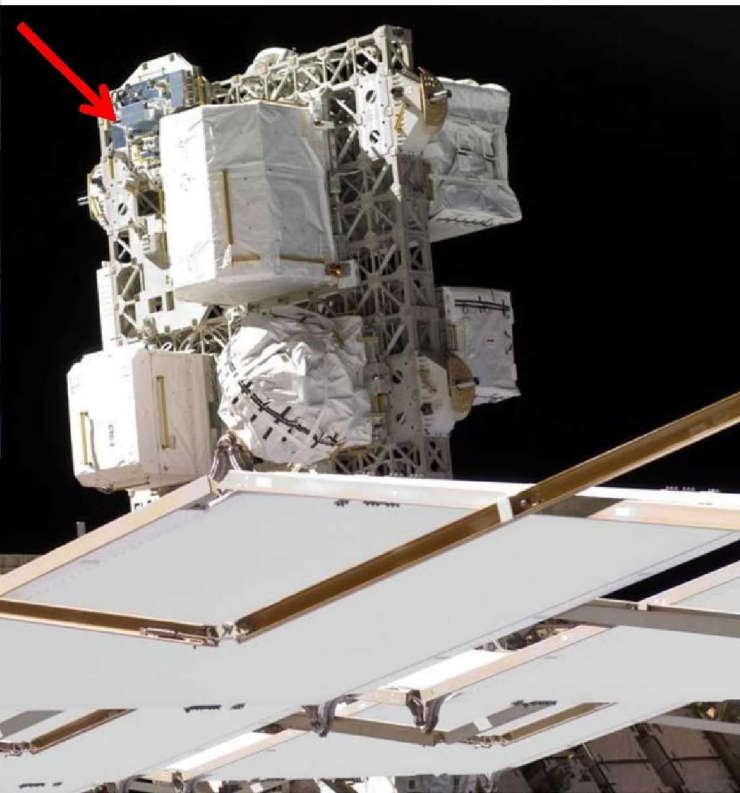
- GSFC SpaceCube 1.0a - Hubble SM 4 (May 2009):
- Autonomous Rendezvous and Docking Experiment
  - Hosted camera AGC and two Pose algorithms



# Software Upset Mitigation



- GSFC SpaceCube 1.0b (Nov 2009):
- “Radiation Hardened by Software” Experiment
  - Autonomous Landing Application
  - Collaboration with NRL

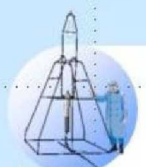


<b>ISS Orbit</b>	
<b>Days Up</b>	<b>157 days 2 hours</b>
<b>Total SEUs</b>	<b>56.00</b>
<b>Avg SEUs/FPGA</b>	<b>14.00</b>
<b>Avg SEUs/FPGA/Day</b>	<b>0.09</b>
<b>Avg SEUs/FPGA/Week</b>	<b>0.62</b>
<b>Avg SEUs/FPGA/Year</b>	<b>32.55</b>



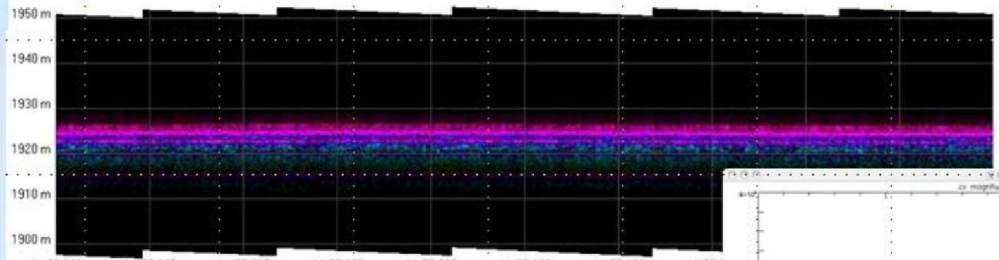


# On-Board Data Reduction



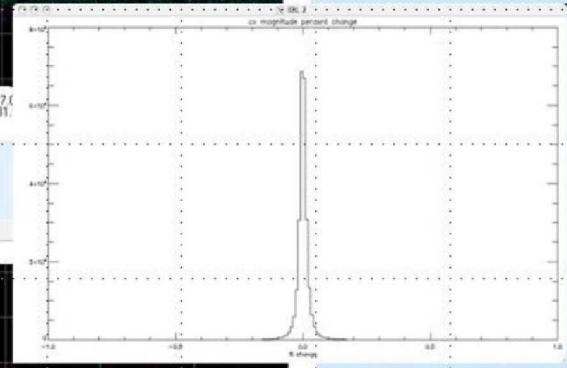
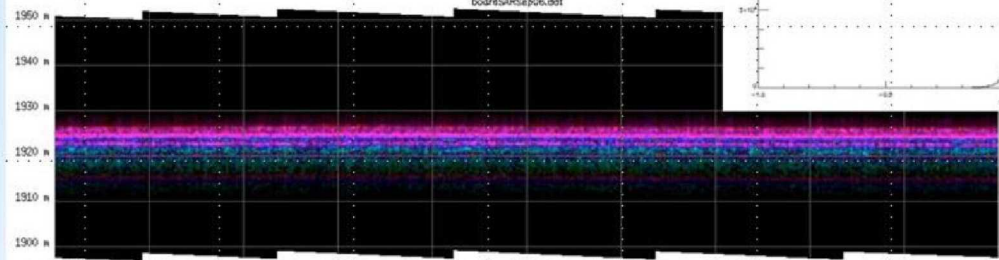
## Accomplishments

SAR Nadir Altimetry Results (FY07)



Original IDL Output

SpaceCube Output



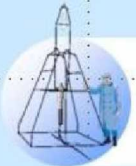
Difference < 0.1%



*On-board processing yields lossless 6:1 data volume reduction*

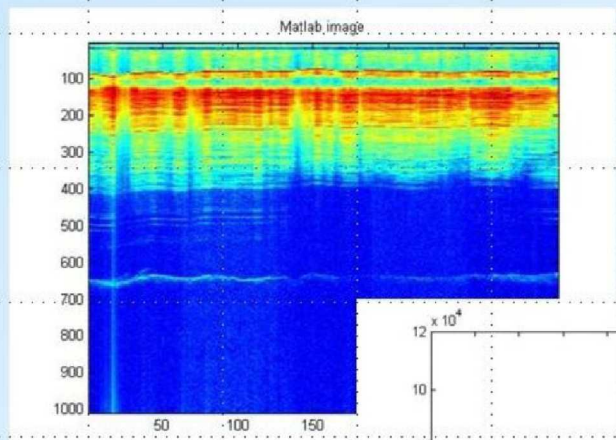


# On-Board Data Reduction



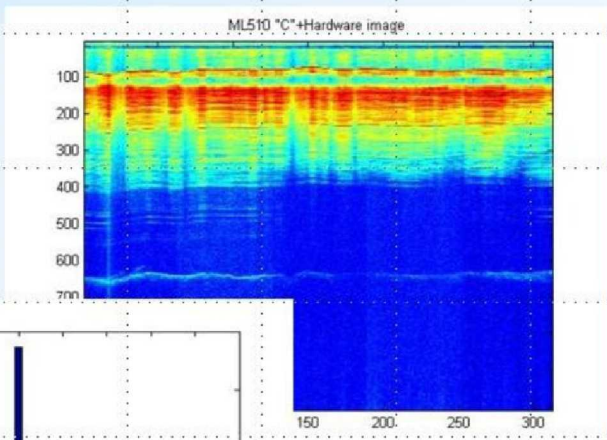
## Accomplishments

### SAR Mapping Results (FY09)



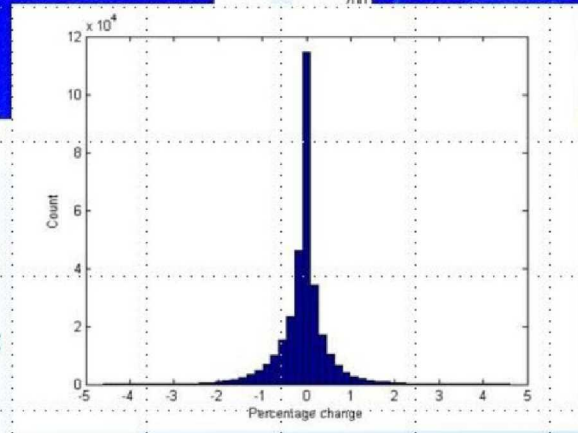
Original Matlab Output

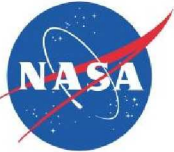
*On-board product generation yields factor of 165x data volume reduction*



SpaceCube Output

Difference < 1%





# On-Board "VSWIR" Products

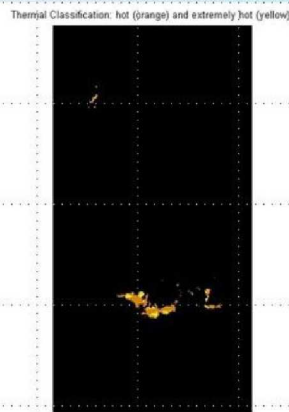
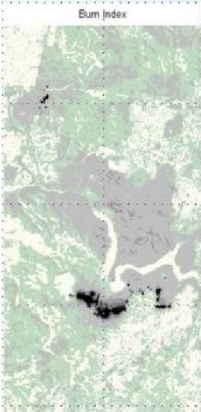


## Accomplishments

- Classification
- Product Generation
- Event Detection

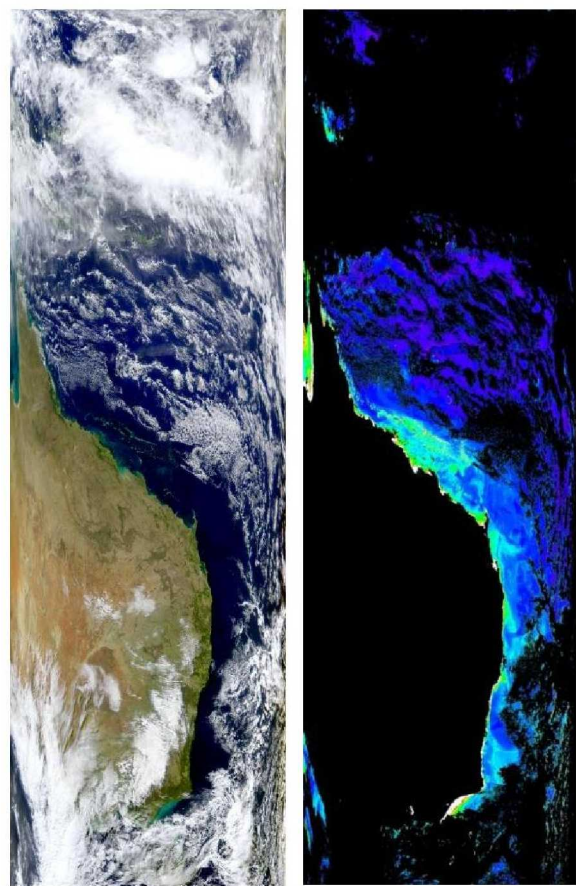
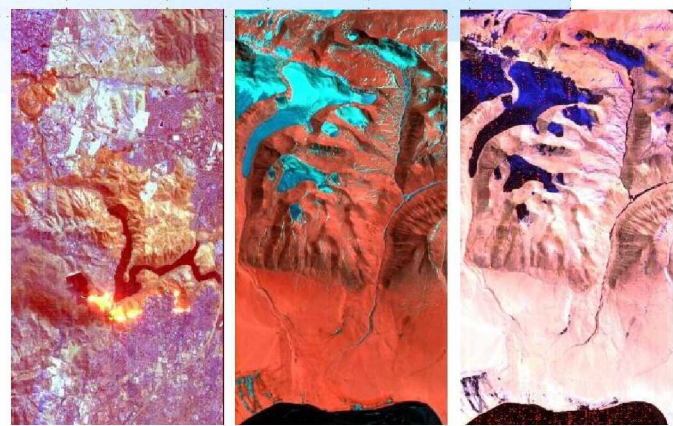


California2007Oct23-bands33-43-155.jpg



On-Board Products

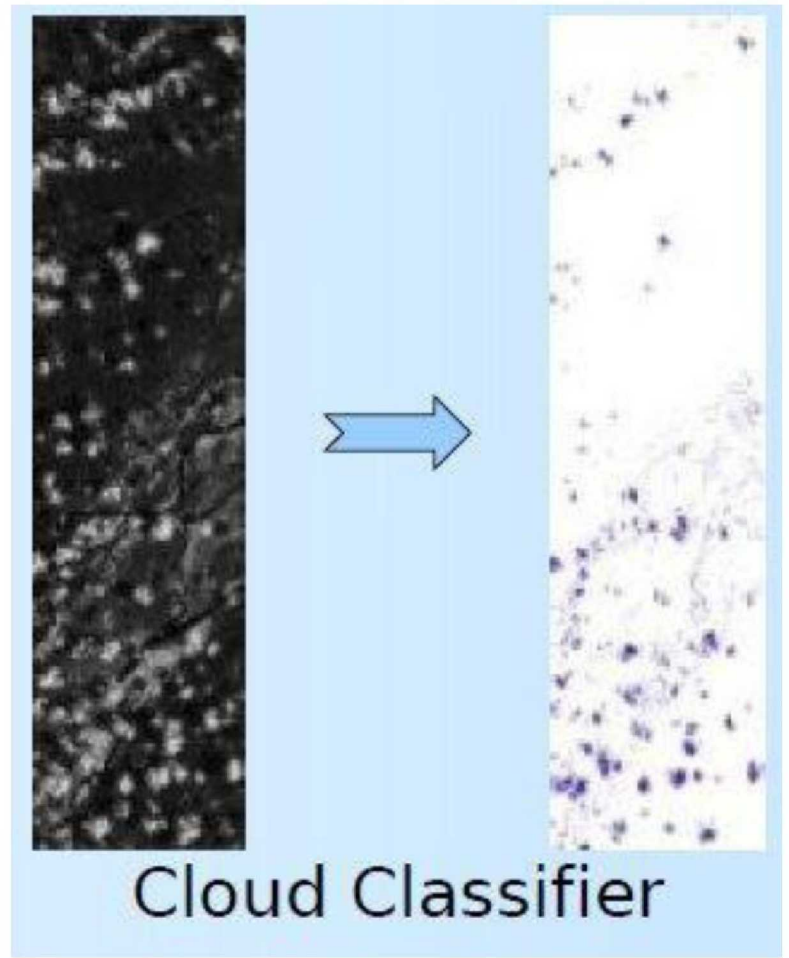
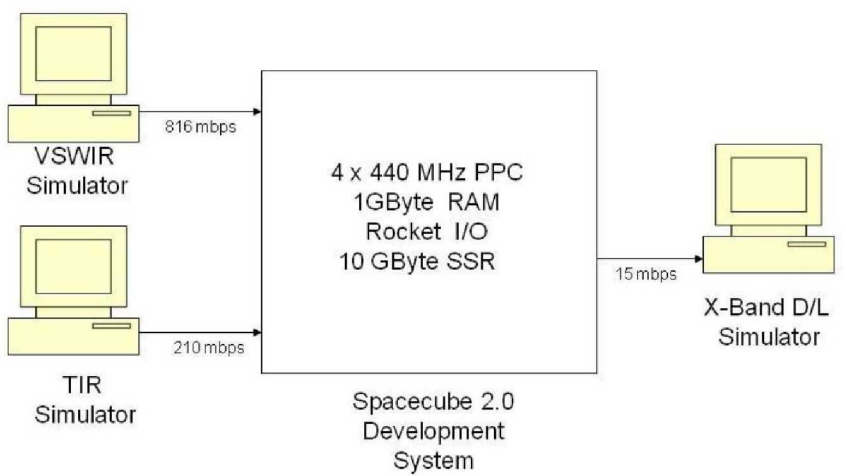
NASA GODDARD SPACE FLIGHT CENTER





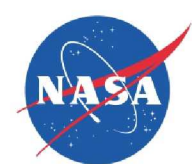
# HyspIRI Demonstration Testbed

## HyspIRI SpaceCube IPM Testbed



Cloud Classifier





# Processor Comparison

	MIPS	Power	MIPS/ W
MIL-STD-1750A	3	15W	0.2
RAD6000	35	10-20W	2.33 <sup>1</sup>
RAD750	300	10-20W	20 <sup>2</sup>
SPARC V8	86	1W <sup>3</sup>	86 <sup>3</sup>
LEON 3FT	60	3-5W <sup>3</sup>	15 <sup>3</sup>
GSFC SpaceCube 1.0	3000	5-15W	400 <sup>4</sup>
GSFC SpaceCube 2.0	5000	10-20W	500 <sup>5</sup>

## Notes:

1 – typical, 35 MIPS at 15 watts

2 – typical, 300 MIPS at 15 watts

3 – processor device only ... total board power TBD

4 – 3000 MIPS at 7.5 watts (measured)

5 – 5000 MIPS at 10 watts (calculated)